REMARKS

Claims 1-20 are pending in the present application. Claims 1, 2, 5, 13, 14, and 17 are amended above. No new matter is added by the claim amendments. Entry is respectfully requested.

Applicant notes, with appreciation, that the Office Action indicates at page 5 that claims 9-12 are allowed. Applicant further notes that the Office Action indicates that claims 7-8 and 19-20 would be allowable if rewritten in independent form. Applicant wishes to defer submission of these claims pending consideration of the present Amendment After Final.

Claims 1-5 and 13-17 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Kawabata *et al.* (U.S. 6,373,533 - hereinafter "Kawabata") in view of Hieda (U.S. 5,818,521). Claims 6 and 18 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Kawabata in view of Hieda and in further view of Kuo et al. (U.S. 5,982,929). It is requested that these rejections be reconsidered and removed in view of the foregoing amendments and the following remarks.

At page 2 of the current Office Action, reasons are indicated for the Examiner's disagreement with the Applicant's position that Kawabata performs amplification in the digital domain on a digital signal. Applicant's statements with regard to this topic from the earlier-filed Amendment of July 28, 2003 are now repeated for convenience:

> In the present invention as claimed in independent claims 1 and 13, therefore, an "analog image signal" is amplified, for example by amplifier 107c of the first signal processing means 107, according to the plurality of different gains of the various respective sections. Following amplification, the analog image signal is converted to a digital signal, for example at the second analog-to-digital converter (ADC) 109a of the second signal processing means 109. Thus, in the present invention, amplification of the analog input signal is conducted in the analog domain.

> Kawabata is directed to a tone correction circuit for correcting the tone of a video signal. Kawabata employs a histogram generator 1 and histogram correction circuit 3 for performing the correction (see Kawabata FIG. 1). The histogram created by the generator 1 is modified using an adjustable gain controller 2. As a histogram is employed, all signal processing, including amplification of the input signal "a", is performed in the digital domain, on a digital input signal "a". This is in contrast with the present invention of claims 1 and 13 in which the image signal of the first signal processing means (see FIG. 1,107) is an "analog image signal". Amplification in the present invention is thus performed in the analog domain on an "analog image signal". Following analog amplification, the present invention of claims 1 and 13 converts the amplified analog image signal to a "digital signal" and "non-linearly gamma-correct[s]" the digital signal, in the digital domain.
>
> Likewise, in Heida, there is no such amplification in the analog domain, of an "analog image signal".

Applicant respectfully disagrees with the Examiner's contention that Kawabata teaches amplification in the analog domain. In further support of Applicant's position that histogram generation, histogram correction, and video signal correction in Kawabata take place in the digital domain, Applicant submits herewith as Appendix A, an excerpt from the text *Fundamentals of Digital Signal Processing*, by Anil K. Jain, Prentice Hall, 1989, pages 241-242. The excerpt includes a discussion of an implementation of histogram modeling for a gray-scale image. It is clear from the discussion that histogram equalization and histogram modification are performed in the discrete-time domain on a digital signal, resulting in a discrete histogram equalization parameter "v". Histogram processing is therefore not performed in the continuous-time, analog, domain, as asserted in the Office Action.

As stated above, in contrast, in the present invention as claimed in claims 1 and 13, the image signal that is partitioned and amplified by the "first signal partitioning means" is an "analog image signal". Thus, the input signal entering amplifier 107c, and amplified therein, is an analog signal. The amplified analog output signal is presented to the second ADC 109a, where it is converted to a "first digital signal" that is non-linearly gamma corrected in the

discrete-time domain by the gamma corrector 109b. Amplification of the analog image signal in this matter confers the benefits outlined in the specification as filed at page 5, lines 14-23 and at page 12, lines 14-24, and overcomes the limitations of the conventional approaches outlined in the specification at page 1, lines 24-29.

In addition, it is submitted that neither Kawabata nor Hieda teaches or suggests amplification of the "analog image signal" according to each of a "plurality of sections" of the partitioned analog image signal, and then also non-linear gamma correction of the amplified and digitally converted image signal "according to the plurality of sections on which the amplification of the analog image signal ... is based", as claimed in claims 1 and 13. An example of this feature is provided in FIG. 1 of the present specification, where it is illustrated that the plurality of sections of the signal output by the first ADC 107a are applied to both the gain selector (for amplifying the analog image signal at amplifier 107c according to selected gains 107b) and the gamma corrector 109b (for performing non-linear gamma correction of the amplified and digitally converted image signal).

Kawabata shows partitioning of a signal into sections that are used for amplification of a digital signal. Hieda shows non-linear gamma correction according to according to signal sections. However, neither reference teaches or suggests using the same, common, sections for both analog amplification and gamma correction, as claimed in independent claims 1 and 13 of the present invention.

Accordingly, reconsideration and removal of the rejections and allowance of independent claims 1 and 13 are therefore respectfully requested. With regard to the various dependent claims, it follows that these claims should inherit the allowability of the independent claims from which they depend.

Closing Remarks

It is submitted that all claims are in condition for allowance, and such allowance is respectfully requested. If prosecution of the application can be expedited by a telephone conference, the Examiner is invited to call the undersigned at the number given below.

Respectfully submitted,

Date: January 22, 2004

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Fundamentals of Digital Image Processing

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Figure 7.12 Range compression.

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in a body. The blood stream is injected with a radio-opaque dye and X-ray images are taken before and after the injection. The difference of the two images yields a clear display of the blood-flow paths (see Fig. 9.44). Other applications of change detection are in security monitoring systems, automated inspection of printed circuits, and so on.

7.3 HISTOGRAM MODELING

The histogram of an image represents the relative frequency of occurrence of the various gray levels in the image. Histogram-modeling techniques modify an image so that its histogram has a desired shape. This is useful in stretching the low-contrast levels of images with narrow histograms. Histogram modeling has been found to be a powerful technique for image enhancement.

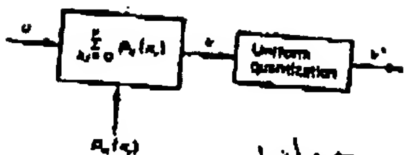
Histogram Equalization

In histogram equalization, the goal is to obtain a uniform histogram for the output image. Consider an image pixel value $u \geq 0$ to be a random variable with a continuous probability density function $p_u(\alpha)$ and cumulative probability distribution $F_u(\alpha) \triangleq P[u \leq \alpha]$. Then the random variable

$$v \triangleq F_u(u) \triangleq \int_0^u p_u(\eta)\,d\eta \tag{7.11}$$

will be uniformly distributed over (0, 1) (Problem 7.3). To implement this transformation on digital images, suppose the input u has L gray levels $x_i, i = 0, 1, \ldots, L-1$ with probabilities $p_u(x_i)$. These probabilities can be determined from the

4



histogram

Figure 7.13 Histogram equalization transformation.

histogram of the image that gives $h(x_i)$ the number of pixels with gray level value x_i. Then

$$p_u(x_i) = \frac{h(x_i)}{\sum_{i=0}^{L-1} h(x_i)}, \quad i = 0, 1, \ldots, L-1 \tag{7.12}$$

: number of pixels with gray level value x_i : total number of pixels

The output v^*, also assumed to have L levels, is given as follows:[†]

$$v \triangleq \sum_{x_i=0}^{u} p_u(x_i) \tag{7.13a}$$

$$v^* \triangleq \mathrm{Int}\left[\frac{(v - v_{min})}{1 - v_{min}}(L-1) + 0.5\right] \tag{7.13b}$$

where v_{min} is the smallest positive value of v obtained from (7.13a). Now v^* will be uniformly distributed only approximately because v is not a uniformly distributed variable (Problem 7.3). Figure 7.13 shows the histogram-equalization algorithm for digital images. From (7.13a) note that v is a discrete variable that takes the value

$$v_k = \sum_{i=0}^{k} p_u(x_i) \tag{7.14}$$

if $u = x_k$. Equation (7.13b) simply uniformly requantizes the set $\{v_k\}$ to $\{v_k^*\}$. Note that this requantization step is necessary because the probabilities $p_u(x_k)$ and $p_v(v_k)$ are the same. Figure 7.14 shows some results of histogram equalization.

Histogram Modification

A generalization of the procedure of Fig. 7.13 is given in Fig. 7.15. The input gray level u is first transformed nonlinearly by $f(u)$, and the output is uniformly quantized. In histogram equalization, the function

$$f(u) = \sum_{x_i=0}^{u} p_u(x_i) \tag{7.15}$$

typically performs a compression of the input variable. Other choices of $f(u)$ that have similar behavior are

$$f(u) = \frac{\sum_{x_i=0}^{u} p_u^{1/n}(x_i)}{\sum_{x_i=0}^{L-1} p_u^{1/n}(x_i)}, \quad n = 2, 3, \ldots \tag{7.16}$$

[†] We assume $x_0 = 0$.